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## Clearing the Cervical Spine in a War Zone: What Other Injuries Matter?

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**ABSTRACT** Background: Cervical spine clearance requires clinicians to assess the reliability of physical examination based on a patient's mental status and distracting injuries. Distracting injuries have never been clearly defined in military casualties. Methods: Retrospective review was conducted of patients entered into Department of Defense Trauma Registry January 2008 to August 2013, identifying blunt trauma patients with cervical spine injury and Glasgow Coma Score  $\geq 14$ . Physical examination and radiology results were abstracted from medical records and injury diagnoses were obtained from Department of Defense Trauma Registry. Groups were compared,  $p$ -value of  $< 0.05$  was considered significant. Results: A total of 149 patients met study criteria; 20 patients (13%) had a negative clinical examination of the cervical spine. Coexisting injuries identified in patients with negative physical examination included injuries in proximity to the neck (head, thoracic spine, chest, or humerus) in 17 (85%) patients. In 3 patients (15%), coexisting injuries were not in proximity to the neck and included pelvic, femur, and tibia fractures. All patients without coexisting injury ( $n = 37$ ) had a positive physical examination. Conclusion: Physical examination of multitrauma casualties with neck injury may be unreliable when distracting injuries are present. When no distracting injuries were present, the physical examination was accurate in all patients.

### INTRODUCTION

Clinical clearance of the cervical spine (c-spine) depends on the clinical judgment of the practitioner after assessing a patient's neurological status, neck tenderness, and distracting injuries. However, the interpretation of distracting injury for the purpose of c-spine clearance has never been clearly defined. Several authors have addressed the question of distracting injury prospectively in single center studies, with divergent conclusions that the physical examination of the c-spine is affected primarily by injuries in proximity to the c-spine,<sup>1,2</sup> that the physical examination of the c-spine was unreliable,<sup>3</sup> and that clinical examination is a sensitive method for detecting c-spine injury and the term "distracting injury" should be eliminated.<sup>4</sup> All of these studies were limited by a small sample size of actual c-spine injuries; there is little evidence to validate or support standard definitions or descriptions of a distracting injury in the clearance of c-spine, and no evidence has been presented from battlefield trauma patients. Battlefield casualties who suffer a blunt

traumatic injury represent a unique subset of the population as predominantly healthy males with a low incidence of intoxication as a contributing factor, blast injury as a common mechanism of injury, and a high incidence of concomitant mild traumatic brain injury (TBI). The aim of this study was to determine if coexisting injuries in battlefield casualties inhibit the ability to identify neck tenderness in an alert patient, thereby preventing a practitioner from clinically clearing the c-spine. Additionally, we sought to explore the relationship between concussion or mild TBI and the results of a clinical c-spine examination.

### METHODS

The Department of Defense Trauma Registry (DoDTR) is the overarching data repository for documenting military casualties, and information that is collected include demographics, mechanism of injury, clinical diagnosis, surgical procedures, and outcomes for all DoD trauma-related injuries. This study was a retrospective review of c-spine-injured patients entered into the DoDTR from January 2008 to August 2013. Inclusion criteria consisted of blunt trauma as the primary mechanism of injury and an Abbreviated Injury Scale code 6402xx.x or 6502xx.x denoting a c-spine fracture or cord injury. Patients were excluded with a Glasgow Coma Score (GCS)  $< 14$ , age  $< 18$  years, or a diagnosis of cervical strain with no fracture or dislocation.

Of those patients who were eligible, medical records were retrieved from the Theater Medical Data Store for documentation about the initial physical examination, including the determination of midline neck tenderness and neurologic deficits by an examining clinician. Patients with documented complaints of neck pain were included with neck tenderness. Military acute concussion evaluation (MACE) scores

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were recorded if available. Only patients with available medical records and computerized tomographic (CT) scan results were included. C-spine CT scans and additional magnetic resonance imaging (MRI) results, if obtained, were recorded and correlated with physical examination findings. Mild TBI was recorded when one of the following was present: loss of consciousness < 30 minutes, skull fracture, or minor intracerebral hemorrhage with GCS 14 to 15. Minor injuries such as abrasions, contusions, or lacerations < 5 cm were not considered as potentially distracting injuries. All open wounds  $\geq$  5 cm, fractures, and other painful injuries were included as coexisting injuries.

Demographic data and concurrent injury diagnoses were abstracted from the DoDTR. Up to three coexisting injuries identified as the most severe for each case were recorded and coexisting injuries were broadly classified by anatomic region as head, torso, or long bone/extremity injuries.<sup>4</sup> To examine the association between coexisting injuries and c-spine examination findings, patients with more than one coexisting injury were classified according to the closest proximity to the neck (head > torso > long bone/extremity). To describe the sample, continuous variables were summarized as mean (standard deviation [SD]) and categorical variables were presented as proportions. To test the associations between coexisting injuries and clinical examination outcomes, chi-square and Fisher's exact tests were performed and a *p*-value of < 0.05 was considered significant. All data analyses were conducted using STATA v.11 (StataCorp, College Station, Texas).

## RESULTS

In total, 545 patients were identified according to the search criteria; 322 were excluded with a diagnosis of cervical strain with no fracture, dislocation, or neurologic deficit. A chart review was conducted for the remaining 223 patients. An additional 74 patients were excluded because of incomplete documentation (*n* = 48), negative imaging and physical examination workup (*n* = 20), age < 18 (*n* = 3), or initial GCS < 14 (*n* = 3), leaving a total sample of 149 patients for analysis (Table I).

The majority of the patients were male (*n* = 143, 96%) and the cause of injury was battle related in 69 (46%). The most common mechanisms of injury were due to an explosive device (*n* = 62, 42%), motor vehicle crash (*n* = 50, 34%), and fall (*n* = 14, 9%). Other injuries were related to helicopter crash (*n* = 6, 4%), blunt object (*n* = 5, 3%), sports (*n* = 5, 3%), machinery/equipment (*n* = 4, 3%), other non-sports (*n* = 2, 1%), and flying debris (*n* = 1, 1%).

Of 149 patients with c-spine injury, 133 (89%) injuries, all fractures, were confirmed by CT. Twelve (8%) injuries, including 7 cases of disc herniation, 3 of ligamentous injury, and 2 of central cord syndrome, were confirmed by MRI after a CT showed no traumatic injury. Four (3%) patients had normal imaging studies of head and c-spine, but had neurologic deficits consistent with spinal

**TABLE I.** Description of Basic Demographics for Military Blunt Trauma Patients With Cervical Spine Injuries (*n* = 149)

Age (mean $\pm$ SD), Year	31.1 $\pm$ 10.9
Male, <i>n</i> (%)	143 (96.0)
Injured During Battle, <i>n</i> (%)	69 (46.3)
Mechanism of Injury, <i>n</i> (%)	
Explosive Device	62 (41.6)
Motor Vehicle Crash	50 (33.6)
Fall	14 (9.4)
Helicopter Crash	6 (4.0)
Blunt Object	5 (3.4)
Sports	5 (3.4)
Machinery/Equipment	4 (2.7)
Other Nonsports	2 (1.3)
Flying Debris	1 (0.7)
MACE Score <sup>a</sup> (mean $\pm$ SD)	24.8 $\pm$ 3.8
Neurological Deficit, <i>n</i> (%)	46 (30.9)
Neck Tenderness During Clinical Examination, <i>n</i> (%)	116 (77.9)
Coexisting Injuries, <i>n</i> (%) <sup>b</sup>	
Any Head Injury (Skull Fracture, Nasal Bone Fracture, Facial Bone Fracture, SAH, SDH, Head or Neck Wound)	62 (33.9)
Any Torso Injury (Rib Fracture, Clavicle Fracture, Scapula Fracture, Pelvic Fracture, Thoracolumbar Spine Fracture, Pneumothorax, Intra-Abdominal Organ Injury)	78 (42.6)
Any Long Bone or Extremity Injury (Femur Fracture, Tibia/Fibula Fracture, Humerus Fracture, Radius/Ulna Fracture, Hip/Shoulder Dislocation)	43 (23.5)

SAH, subarachnoid hemorrhage; SDH, subdural hematoma. <sup>a</sup>*n* = 124 missing MACE score. <sup>b</sup>*n* = 149 patients, 183 injuries in total.

cord injury and were diagnosed with spinal cord injury without radiologic abnormality.

During an initial physical examination, 78% of the patients (*n* = 116) reported midline c-spine tenderness and approximately one-third (*n* = 46, 31%) demonstrated a neurologic deficit. A total of 20 c-spine-injured patients (13%) had a negative physical examination of the c-spine, defined as no midline tenderness and no neurologic deficit documented. There was no statistically significant relationship between the mechanism of injury (e.g., explosive device, motor vehicle collision, etc.) and the outcome of the physical examination (*p* = 0.356). MACE scores were available for only 25 patients and the mean MACE score was 24.8  $\pm$  3.8, with a suggested cutoff score of 25 (maximum score 30) indicating a threshold for clinically relevant cognitive impairment.<sup>5</sup>

Among the c-spine injuries in 20 patients with negative physical examinations, the most common injuries were transverse process (7/20, 35%) and facet (5/20, 25%) fractures, although other significant fractures were detected (Table II). The proportions of these c-spine injuries in patients who reported c-spine tenderness (*n* = 116) or neurologic deficit (*n* = 46) are presented in Table II for comparison. Of the patients with midline neck tenderness, the large majority (83/116, 72%) reported only neck tenderness without any neurologic deficits noted. Mild TBI was documented in 68% of the total patient sample (*n* = 102).

**TABLE II.** Specific Cervical Spine Injuries Identified in Patients (Based on Clinical Examination Outcomes),  $n = 149$  Patients With Confirmed Cervical Spine Injury

Injury Diagnosed by CT Scan	Negative Examination <sup>a</sup> $n$ (%)	Neck Tenderness $n$ (%)	Neurologic Deficit $n$ (%)
Transverse Process Fracture	7 (35%)	11 (9%)	1 (2%)
Facet Fracture	5 (25%)	21 (18%)	15 (33%)
Vertebral Body/Compression Fracture	2 (10%)	31 (27%)	8 (17%)
Spinous Process Fracture	2 (10%)	20 (17%)	4 (9%)
Odontoid Fracture	2 (10%)	1 (1%)	—
Lamina/Pedicle Fracture	1 (5%)	9 (8%)	2 (4%)
Burst Fracture	1 (5%)	9 (8%)	6 (13%)
Disc Herniation	—	4 (3%)	4 (9%)
Spinal Cord Injury With/Without Fracture	—	6 (5%)	6 (13%)
Ligament Disruption	—	3 (3%)	—
Occipital Condyle Fracture	—	1 (1%)	—
Total	20 (100%)	116 (100%)	46 (100%)

<sup>a</sup>Negative physical examination defined as no midline neck tenderness and no neurologic deficit.

**TABLE III.** Coexisting Injury by Clinical Examination Outcomes,  $n = 149$  Patients With Confirmed Cervical Spine Injury

Coexisting Injury <sup>a</sup>	All Patients $n$ (%)	Neck Tenderness	Neurologic Deficit	Negative Examination <sup>b</sup>
Head Injury	62 (42%)	47	15	12
Torso Injury	39 (26%)	31	15	5
Long Bone/Extremity Injury	11 (7%)	8	—	3
No Coexisting Injury	37 (25%)	30	16	—
Total	$n = 149$ (100%)	116	46	20

<sup>a</sup>Patients with more than one type of coexisting injury were classified according to the closest proximity to the neck (head > torso > long bone/extremity).

<sup>b</sup>Negative examination defined as no midline neck tenderness AND no neurologic deficit.

Nearly half ( $n = 62$ , 42%) of the patients had coexisting injuries to the head region and most in this group had neck tenderness (47/62, 76%) and mild TBI (51/62, 82%) (Table III). Neck tenderness was present in a similar percentage of patients with torso injuries (31/39, 79%), and there was no statistically significant relationship between the predominant type of coexisting injury and the clinical finding of neck tenderness ( $p = 0.683$ ). Reported neurologic deficit ( $p = 0.013$ ), mild TBI ( $p = 0.016$ ), and an overall negative physical examination ( $p = 0.007$ ) were significantly associated with the predominant type of coexisting injury. There was no statistically significant relationship between the results of a c-spine physical examination and the occurrence of mild TBI ( $\chi^2$  with 1 degree of freedom = 0.0255,  $p = 0.873$ ).

Twenty-five percent ( $n = 37$ ) of c-spine-injured patients had no significant coexisting injuries beyond mild TBI. All of these patients had a positive physical examination of the c-spine, demonstrating tenderness ( $n = 30$ ) and/or neurologic deficit ( $n = 16$ ).

Of the patients with a negative physical examination of the c-spine ( $n = 20$ ), most (12/20, 60%) did have coexisting head injuries in close proximity to the neck (Table IV). In three patients, the only coexisting injuries were in the lower extremities: one pelvic fracture, one femur fracture, and one tibia fracture (patients 36, 50, and 72). Coexisting injuries

identified in c-spine-injured patients with a negative physical examination are detailed in Table IV.

## DISCUSSION

Clinical clearance of the c-spine without radiologic imaging conserves resources by avoiding unnecessary imaging in patients identified to be at very low risk of c-spine injury. In the military environment where trauma often occurs in austere settings with limited resources, the ability to clinically clear the c-spine is especially valuable because accurate screening or risk assessment may avoid unnecessary evacuation to obtain imaging.

The aim of this study was to examine the role of distracting injuries and c-spine clearance in polytrauma patients drawn from a military population. We theorized that c-spine-injured patients with a negative examination may have relatively insignificant injuries that do not affect the structural integrity of the spine. Our findings, however, revealed very significant fractures, including facet fractures, odontoid fractures, compression and burst fractures, and lamina/pedicle fractures, among patients who did not present with clinical symptoms.

From our sample of 149 c-spine-injured patients, we identified 20 patients with an initial physical examination that was negative with no reported midline neck tenderness or neurologic deficit despite confirmed c-spine injury. A majority of

**TABLE IV.** Cervical Spine Injuries Among Patients With Negative Clinical Examination ( $n = 20$ )

Gender	Age (Year)	Mechanism of Injury	GCS	Concussion	Distracting Injuries	C-Spine CT
Male	21	Fall	15	Yes	860.0, Traumatic pneumothorax, closed 807.2, Sternum fx closed 805.2, Fracture dorsal vertebra, closed	C7-T2 transverse process fx
Male	57	Fall	15	Yes	805.2, Fx dorsal vertebra, closed	C7 transverse process fx
Male	27	MVC	15	Yes	873.0, Open wound of scalp 802.0, Nasal bone fx, closed 873.40, Open wound of face unspecified site	C7 spinous process fx
Male	35	Explosive Device	15	Yes	808.8, Unspecified pelvic fx closed 825.21, Fx astragalus (talus) closed 873.64, Open wound of tongue and floor of mouth	C6 transverse process fx
Male	43	Helicopter Crash	15	No	802.1, Nasal bone fx, open 807.04, Rib fx closed, four ribs 811.00, Fx scapula closed NFS	R C7 TP fx
Male	29	MVC	15	—	873.0, Open wound of scalp	Non-displaced type II odontoid fx
Male	19	Explosive Device	15	Yes	821.11, Fx femur—shaft open	C7 right superior articular process fx, nondisplaced
Male	31	Helo Crash	15	—	807.02, Rib fx closed, two ribs 811.00, Fx scapula closed NFS 823.81, Fx fibula unspecified closed	C6 superior L facet fx
Male	23	Machinery/Equipment	14	Yes	805.2, Fx dorsal vertebra 807.02, Rib fx closed, two ribs 873.0, Open wound of scalp	C6 lamina/pedicle fx
Male	25	Explosive Device	15	Yes	823.20, Fx tibia shaft closed 904.41, Injury to popliteal artery 826.0, Fx one or more phalanges of foot closed	C7 transverse foramen/facet fx
Male	24	MVC	15	—	873.0, Open wound of scalp 832.02, Posterior dislocation of elbow closed 811.00, Fx scapula closed NFS	C7 transverse process fx
Male	45	MVC	15	Yes	820.8, Fx femur - unspecified part of neck closed 807.01, Rib fx closed, one rib 802.4, Fx malar/maxillary, closed	C4 facet fx
Male	19	Explosive Device	15	Yes	873.40, Open wound of face unspecified site 873.63, Open wound of tooth	C5 compression fx
Male	36	MVC	15	Yes	873.0, Open wound of scalp	C7 spinous process fx
Male	28	Explosive Device	15	Yes	807.4, Flail chest 860.4, Traumatic pneumohemothorax, closed 805.4, Fx lumbar vertebra, closed	C7 transverse process fx
Male	31	Explosive Device	15	Yes	802.24, Fx ramus NOS, closed, mandible 860.0, Traumatic pneumothorax, closed 805.4, Fx lumbar vertebra, closed	C6 transverse process fx (through transverse foramen)
Male	30	MVC	15	—	805.2, Fx dorsal vertebra, closed, T9 compression fx 860.0, Traumatic pneumothorax, closed	C6 burst fracture
Male	29	Helicopter Crash	15	Yes	800.10, Closed skull vault fx, cerebral contusion 807.06, Rib fx closed, six ribs 813.43, Fx of ulna distal end closed	Bilateral C7 lamina fx, C7 right inferior facet fx
Male	30	Explosive Device	15	—	812.40, Fx humerus lower end closed NFS 824.8, Fx ankle NOS closed 825.0, Fx calcaneus closed	C5 compression fx
Male	25	MVC	15	Yes	941.08, Burn NOS of neck	C2 Type III dens fx

fx, fracture; MVC, motor vehicle collision; NFS, not further specified; NOS, not otherwise specified.

these blunt trauma patients did have at least one coexisting injury in close proximity to the neck; however, three patients had only lower extremity injury. These findings support the conclusion that any painful injury, including those remote from the c-spine, may contribute to a missed diagnosis if spinal clearance is based on the results of a c-spine clinical examination alone.

We also noted that all of the c-spine-injured patients who had no significant coexisting injury did have a positive physical examination of the c-spine, demonstrating tenderness and/or neurologic deficit. This supports previous recommendations that the c-spine can be cleared based on physical examination when significant coexisting injuries are not present.

The two established criteria developed to guide the clinical clearance of the c-spine after blunt trauma include the National Emergency X-Radiography Utilization Study (NEXUS) criteria<sup>6</sup> and the Canadian Cervical Spine Rule.<sup>7</sup> The common goal of both tools is to reduce unneeded radiography by reserving these measures for patients with a greater likelihood of c-spine injury. Both the NEXUS and Canadian Cervical Spine Rule are highly sensitive approaches according to a recent review<sup>8</sup> and are considered generally effective for managing clearance of the c-spine to potentially minimize unnecessary imaging in civilian settings.

The Canadian Cervical Spine Rule relies upon three main questions to determine the requirement for imaging: (1) is there a high risk factor present (i.e., age  $\geq$  65 years, dangerous mechanism, or paresthesia), (2) is there a low risk factor that allows for safe assessment of range of motion (i.e., simple rear-end motor vehicle collision, sitting position and ambulatory since injury, delayed onset of neck pain, or absence of midline c-spine tenderness), and (3) is the patient able to actively rotate neck 45° left and right? Applying the Canadian Cervical Spine Rule within the combat environment may lead most physicians to order imaging based on the mechanism of injury.

Using the NEXUS criteria to clinically clear a patient of a c-spine injury without imaging requires the following: a normal level of alertness, no focal neurological deficit, no tenderness at the posterior midline of the c-spine, and no clinically apparent painful distracting injury. In the original NEXUS publication, there was no attempt to further define a distracting painful injury and this was left to clinical judgment. Several investigators have subsequently attempted to define or characterize a distracting injury as it pertains to c-spine clearance. In general, these studies are in agreement that injuries in close proximity to the c-spine contribute to the false negative finding of a clinical examination, whereas injuries located more distally or remote from the c-spine are less likely to produce a false negative examination. A prospective study by Heffernan et al<sup>1</sup> supports this hypothesis with 7/40 (18%) patients with a c-spine fracture presenting with a nontender c-spine, which represented only 2.9% of all participants with nontender neck. All patients with a false negative physical examination had upper torso injuries including thoracic fractures and scalp lacerations. Konstantinidis et al<sup>2</sup> described four patients with a nontender c-spine on examination and a fracture present. All four patients had thoracic injuries, such as rib fractures or a significant chest contusion, suggesting that thoracic injuries, in particular, may contribute to a negative c-spine examination of evaluable blunt trauma patients. Duane et al<sup>3</sup> published similar findings from a group of blunt trauma patients with an initial GCS of 15, and 12/52 (23%) of the patients with a c-spine fracture had a negative clinical examination, that included a subset 7 of 17 (41%) patients who were not intoxicated and had no distracting injuries. On the basis of these results, the authors argue that conducting a clinical examination is not reliable to

rule out a c-spine fracture. In contrast, a prospective study by Rose et al<sup>4</sup> in 2012 found 2 of 86 (2.3%) patients with c-spine fracture had a negative clinical examination, including one patient with a humerus fracture, mandible fracture, and left frontal intracranial contusion and one patient with "no distracting injuries." These authors concluded that clinical examination is a sensitive method for detecting c-spine injury and recommended that the term "distracting injury" should be abandoned. An important difference to note in the study by Rose et al is that the c-spine examination included testing the range of motion of the c-spine, in contrast to other studies and our study in which pain and tenderness were assessed without examining the voluntary flexion and extension or range of the neck. Our study contradicts previous studies that attempted to define distracting injury and suggests that any significant injury, even isolated to the lower extremity, is associated with a negative c-spine examination in the presence of c-spine injury.

A high rate of mild TBI (68%) was documented in this patient population; however, we did not detect any relation between mild TBI and a negative physical examination in c-spine-injured patients.

This study was limited by its retrospective nature, which did not permit follow-up of patients with a documented negative c-spine examination to determine if any later presented with midline c-spine tenderness or other clinical symptoms. Similarly, data drawn from DoDTR and medical records prescribed which clinical variables could be collected and analyzed in contrast to a more expansive assessment that could be conducted as part of a prospective study. Information about patients without c-spine injuries and the specificity of the screening measures could also be derived from a prospective study design.

The strengths of the study include the relatively large sample size of confirmed c-spine injured patients that encompasses all military casualties recorded for approximately a 5-year period. C-spine injuries were confirmed with radiography results, and physical examinations conducted in military medical settings typically follow standardized practice guidelines. Recall bias is minimized because the data are recorded and collected prospectively for entry into the collaborative registry. To our knowledge, this analysis represents the largest evaluation of coexisting injuries in c-spine-injured patients from a military population.

## CONCLUSION

Physical examination of multitrauma casualties with neck injury may be unreliable when distracting injuries are present. When no distracting injuries were present, the physical examination was accurate in all patients. A negative examination was reported in casualties with coexisting injuries who were found to have significant c-spine injuries, and some of the coexisting injuries were exclusively in the lower extremities. Mild TBI did not significantly affect the examination of the c-spine.

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